

# ***Data Integrity***

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- We all need to consider reliability of data in terms of what is cost effective to us and viable from the perspective of the vendors
- Vendors are not going to make products that can only be sold in a small market segment
  - Unless there is extremely high profit margins
- Preservation archives need extreme reliability that is not required in the most markets
  - Consumer, SMB, E-commerce, etc
- How do we resolve these two opposing seemingly intractable positions?

- Disk and tape density increases from the 1990s have slowed
- Significant loss of the tape market to data de-duplication
- Disk density has increased, but not relative to reliability
  - This has caused a number of market trends such as:
    - Remote replication of disk storage
    - RAID-6
- No changes expected in technology hard error rates
- Hierarchical Storage Management (HSM) has been used to extend the file system from disk to tape
  - UNIX based HSMs have been around for 20 years

- Most of the requirements (likely over 90%) are similar
- A few of the big areas of difference between the two are:
  - 1. File sizes tend to be smaller in Preservation archives
  - 2. The need for data reliability is far higher in Preservation archives compared to Scientific archives

- Some of the typical requirements are:
  - Per-file checksums with automatic failure recovery
  - Automatic migration to new formats and technology
  - Significant scaling without loss of data integrity
  - All at a reasonable cost
  - Sometimes these requirements are legislated
- Loss or corruption of a single bit of data is a significant issue
  - This is completely different than most scientific archives
    - Most data can be regenerated by re-running the input
  - It might be similar to medical record archives
  - Broad market trends are supporting scientific archives

- The current belief is that cheap hardware can be made reliable with auto-replication and constant checksum validation
- This method has basically traded the cost of power and cheap hardware for seemingly complex HSM software and tapes
- Upfront costs and initial management cost are often lower than for HSM
- The total cost models for this method have yet to be proven to be cost effective over HSM
- Used by frameworks such as Hadoop MapReduce
- Most importantly, these methods are considered modern, while HSMs are considered old and decrepit (your grandfather's technology)

- Mismatch of Preservation archive requirements and broad market development trends
- No standard framework to meet the Preservation community's objectives for digital content management (aka Information Lifecycle Management or ILM)
- Results:
  - Significant cost to the Preservation community in the development of software frameworks for ILM features
  - Significant cost to the Preservation community in the development of hardware architectures to support ILM features

# ***Backup Slides***

- What data reliability level do you want?

Data Loss in Bytes						
9s	Data Reliability %	1 PB	50 PB	100 PB	500 PB	1 EB
2	99%	90,071,992,547,410	4,503,599,627,370,500	9,007,199,254,741,000	45,035,996,273,705,000	92,233,720,368,547,800
3	99.9%	9,007,199,254,741	450,359,962,737,050	900,719,925,474,100	4,503,599,627,370,500	9,223,372,036,854,780
4	99.99%	900,719,925,474	45,035,996,273,700	90,071,992,547,400	450,359,962,737,000	922,337,203,685,376
5	99.999%	90,071,992,547	4,503,599,627,350	9,007,199,254,700	45,035,996,273,500	92,233,720,368,128
6	99.9999%	9,007,199,255	450,359,962,750	900,719,925,500	4,503,599,627,500	9,223,372,037,120
7	99.99999%	900,719,925	45,035,996,250	90,071,992,500	450,359,962,500	922,337,203,200
8	99.999999%	90,071,993	4,503,599,650	9,007,199,300	45,035,996,500	92,233,720,832
9	99.9999999%	9,007,199	450,359,950	900,719,900	4,503,599,500	9,223,371,776
10	99.99999999%	900,720	45,036,000	90,072,000	450,360,000	922,337,280
15	99.9999999999999%	9	450	900	4,500	9,216
20	99.99999999999999%	0	0	0	0	0

- How much reliability can you afford given current technology?
  - Not as much as you think!